HYCAL

ANDERSON - SOUTH PIERSON FORMATION SENSITIVITY STUDY

Prepared for

Anderson Exploration Limited

Prepared by

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SUMMARY

SUMMARY

Study Objective

At the request of Saad Ibrahim of Petro Management Group acting on behalf of Anderson Exploration Limited (Anderson), Hycal Energy Research Laboratories Ltd. conducted a formation sensitivity study using reservoir material from the Spearfish formation in the South Pierson area. This study was initiated to evaluate this formation's sensitivity to water injection rates in a horizontal and vertical well scenario and filtering requirements. The objective of this study was to evaluate filtration limits and the onset of fines migration using critical filtration tests and critical velocity tests.

Conclusions

The following conclusions are provided to enhance understanding of the laboratory data and to offer additional insight relative to Hycal's experience with laboratory and field processes. They represent our interpretation as to possible mechanisms and physical phenomena that may be occurring within the laboratory models that have been studied. However, these laboratory experiments are microscale representations of the field scenario and macroscale phenomena may override behaviour exhibited in the laboratory. A more thorough development of these conclusions is presented in the Discussion section of the report.

1. Critical filtration test results indicated that some injectivity impairment occurred at a filter size of 3 micron with high quality samples. Lower quality samples exhibited injectivity impairment at all filter sizes of greater than 0.5 microns. With current filter size being 3 microns and the majority of the injection occuring at the higher quality zones of the reservoir, our recommendation is that the filter size be reduced to at least 2 micron in size. Of course, further reduction in filter size will benefit the reservoir as a whole.

2. Results of the fines migration (critical velocity) tests exhibited dramatic sensitivity to injection flow rates. At the current injection rate of 2-4 m3 per day in a vertical well scenario, test results suggested that a lost of 35% to 60% of injectivity may have already occurred. However, at the proposed injection rate of 50-70 m3 per day in a horizontal well scenario, the effective interstitial velocity would be reduced by nearly 4 fold. Thus the injectivity would be greatly enhanced.

DISCUSSION

DISCUSSION

Core materials were obtained from three wells drilled in the South Pierson area to represent the Spearfish formation. The plug samples were drilled using a potassium chloride brine and no further cleaning of the samples were conducted to avoid further damage to the in-situ clay materials. Routine air permeabilities and porosities of these samples are shown in Table 1. Field samples of the injection sour water was obtained and utilized for the critical filtration tests and the fines migration tests. A confining pressure equivalent to 39760 kPag of reservoir net overburden was applied to the test samples.

Cores #HY7B, HY16A - Critical Filtration Test

Two samples of lower reservoir quality were mounted together to form a composite core stack for this critical filtration tests. Five filters sizes of 3.0 micron of less were selected for testing. The current filter size used in the field is 3.0 microns and the concern here is whether if there is justification to reduce this filter size. The finest filter sized tested was 0.2 micron. The filter sizes increased to 0.5, 0.8, 2.0 and finally 3.0 micron. With this core stack, only the 0.2 micron filter produced a stable permeability measurement. Further increases in filter sizes resulted in decreases in permeability. At the maximum filter size of 3.0 micron, the end point permeability after 20 pore volume injection was only 46% of the original permeability measured with a 0.2 micron filter size. Tabulated results for this test are shown in Table 2 and 3 and graphically in Figure 3.

Cores #HY7A, HY21 - Critical Filtration Test

The second critical filtration test was done on two samples representing the high quality zones of the reservoir. The plug samples were stacked together. The majority of the injection in the field is believed to occur into zones of this higher permeability. The effective permeability generally stayed constant from filter size of 0.2 microns up to 2.0 microns, with a slight declining trend with continue injection at the 3.0 micron filter size. The median pore throat size is believed to be near 10 micron range (Anderson's data pool) for the higher permeability zones and the 3.0 micron size falls in the 1/3 median pore size rule. The results supports that a decrease in filter size will enhance injectivity. However, the limits of filter size may be decided by economic and practicality of filter replacement and efficiency. Tabulated results are shown on Table 3 & 4 and shown graphically on Figure 4.

Core #HY33 - Fines Migration Test with Injection Water

Under the current practice, injection into a vertical well of 3 to 4 meter in perforated zone is around 2-4 m^3 per day. In the proposed horizontal injection wells, the targeted injection rate will be 50 to 70 m^3/day into a horizontal leg of approximately 600 meter long. The laboratory flow rates used in the fines migration tests encompass the injection rates of both scenarios and beyond.

For sample HY33, a baseline permeability was established at a lab flow rate of 1 cc/hr, which translates to a injection rate of approximately 0.16 m^3/day in the vertical well scenario and 25 m^3/day for the horizontal well scenario. As the flow rate was increased, the effective permeability decreased dramatically. At a laboratory flow rate of 3 cc/hr, which translates to nearly 77 m^3/day in the horizontal well scenario, the effective permeability dropped by 30%. At a lab flow rate of 16 cc/hr, which translates to 2.6 m^3/day for the vertical well scenario; which is approximately the current injection rate; the effective permeability decreased to only 40% of the baseline measurement. Overall, the injectivity decreased dramatically with increases in flow rate. The tabulated results are shown in Table 6 & 7 and a plot of the permeability vs. flow rate is shown in Figure 5.

Core #HY16B - Fines Migration Test with Injection Water

The same set of flow rates was applied to this sample as for the previous sample. A similar decrease in permeability was observed for the first four flow rates. However, the next two flow rates resulted in permeabilities higher than the pervious flow rates. This is actually an indication of fines migration as mobile fines in a core sample may be produced through and out of the test core plug and results in a increase in permeability. This is a laboratory artifact. In a field situation, the depth of flow would not allow fines to flow through and out of the reservoir. Thus, the net effect in the field would be a further decrease in permeability. The tabulated results for this test is shown in

Table 8 & 9. The plot of permeability vs. flow rate is shown in Figure 6. Also in Figure 6, a dashed line is drawn to estimate the net effects of the fines migration without the laboratory effects.

In conclusion, the injectivity would benefit from a decrease in filter size in the field to less than 3 microns. For practical application, a filter of 1.0 micron would likely perform very well. Filter sizes of less than 1 micron will tend to plug up very fast and injection will likely be bypassed or face severe pressure drop. The injectivity will also be greatly enhanced by the use the horizontal wells. The proposed horizontal wells will reduce the interstitial velocities significantly when compared to the vertical well. As the fines migration test results indicates, the current vertical injection wells may have suffered severe loss of injectivity already.

PROCEDURES &
EQUIPMENT

PROCEDURE

Core Handling and Preparation

Core material for the study was obtained from the following wells in the South Pierson area to represent the Spearfish formation.

Well I.D. & Location	Interval
Home S. Pierson 08-08-002-29 W1M	1031 m - 1035 m
Home S. Pierson 12-09-002-29 W1M	1023 m - 1028 m
Home S. Pierson 14-09-002-29 W1M	1023 m - 1027 m

Small plugs (1½ inch in diameter) were drilled from the full diameter core material using a 3% potassium chloride solution as lubrication. The samples were subjected to a special cleaning process using methanol and chloroform in an effort to remove hydrocarbon that may be in the pore spaces. Routine air permeability and helium expansion porosity were measured on these samples to aid in the selection of representative core material for testing. Table 1 summarizes the routine analysis for the samples.

Critical Filtration Test

The core material used for critical filtration testing was mounted as outlined in the "Description of Equipment" section of this report. Specified reservoir conditions of temperature and net overburden confining stress were utilized to obtain representative conditions for the experimental process. The following critical filtration procedure was then employed.

Critical Filtration Procedure

1. Bring the mounted core material to the test temperature and apply net overburden pressure to obtain representative rock compression and absolute permeability characteristics for the reservoir test material.

2. Displace field water through the core with a fine tolerance filter to obtain an initial stabilized baseline permeability to the injection water before suspended particles are introduced into the pore system.

3. Change the filtration level of the injection water phase to allow a specified maximum particle size to enter into the pore system. Measure permeability versus cumulative pore volumes injected to evaluate the sensitivity of the pore system to the water at the specified filtration level.

4. Change the filtration level of the injection water using incrementally increasing maximum particle size tolerance and measure the permeability at each filtration level to evaluate the susceptibility of the matrix to impairment at the various filtration levels.

Fines Migration Test

The core material was initially in a clean state prior to testing and specified reservoir conditions of temperature and net overburden confining stress were utilized to obtain representative state for the displacement series. The following fines migration procedure was used to determine the propensity for migration of pore space particulates in a high shear environment.

Fines Migration Procedure

1. Mount the core in a flexible sleeve. Apply the specified net overburden pressure and heat the core to reservoir temperature.

2. Flood the core with filtered non-damaging formation water.

3. Displace filtered formation water through the core at a base rate velocity and determine the initial stabilized permeability of the core material.

4. Increase the injection rate and displace formation water to achieve steady state pressure differential. Reduce the rate to base rate velocity and measure the stabilized permeability of the core and calculate any change in the baseline permeability caused by the elevated flow rate.

5. Repeat step 4 at incrementally increasing injection rates (i.e. reducing the rate to the base rate velocity for each permeability measurement) to facilitate the development of a plot indicating the permeability versus rate relationship.

DESCRIPTION OF EQUIPMENT

General Displacement Test Equipment

Equipment that is used in conventional displacement experiments is common to most core flow evaluation techniques. Detailed schematics of the specific apparatus configuration are provided in Figure #1 of this report. General descriptions of the laboratory equipment utilized for these tests appear in the following paragraphs.

Conventional Core Flow Heads

The portions of the core holder directly adjacent to the injection and production ends of the core are equipped with radial distribution plates to ensure that fluid flow is uniformly distributed into and out of the core sample. These heads are used for experiments which involve fluids that are prefiltered to remove large suspended solids which could become entrained in the flow ports. All wetted surfaces of the flow equipment use conventional 316 SS.

Pressure Measurement

Pressure differential is monitored using Validyne pressure transducers. The transducers are mounted directly across the core and measure the pressure differential between the injection and production ends. The pressure transducers have ranges of sensitivity ranging from 0 to 14 and 0 to 26000 kPa and is rated as accurate to 0.01% of the full scale value. The appropriate transducer size is selected based upon the expected permeability and associated range of accompanying differential pressures for a given core sample. The signal from the pressure transducer appears on a multi-channel digital Validyne terminal from which the test operator records pressure readings during the displacement processes. The signal can also be downloaded to a computerized continuing data acquisition system for long term runs.

Temperature Control

The core holder and associated injection fluids are contained in a temperature controlled air bath to simulate reservoir temperature. The oven contains a circulating air system to eliminate internal temperature gradients and can control at temperatures from 20 to 200°C with a rated accuracy of ±1°C.

Fluid Displacement

A highly accurate positive displacement pump is used to inject fluids into the core. The pump can inject fluids at rates from 0.6 to 8200 cm^3/hr and at pressures of up to 68.9 MPa, with an accuracy of ± 0.01 cm^3. The pump is filled with distilled water that displaces hydrocarbon fluid, test fluid or immiscible buffer fluid which in turn displaces test fluid into the core relative to the specific application. The experimental system has been designed to minimize dead volumes and to ensure that the entire system is at pressure equilibrium prior to any fluid change. Backpressure on the system (for full reservoir condition tests) is controlled using a 316 SS controlling backpressure regulator rated accurate to 0.5% of the setpoint value. This regulator allows for the smooth production of fluids from the system at any required flowrate and setpoint pressure.

TABLES

TABLE 1
ANDERSON - S. PIERSON
FORMATION DAMAGE STUDY
ROUTINE CORE ANALYSIS

Sample No.	Depth (m)	Air Permeability (mD)	Porosity (fraction)	Grain Density (kg/m^3)	Comments
[illegible]					
HY 23	1031.02	1.92	0.126	2720	
HY26	1031.80	2.81	0.181	2700	
HY 27 *	1032.22	16.8	0.170	2700	* Fractured sample
HY 30	1032.90	12.2	0.222	2690	
HY 31	1033.17	22.5	0.205	2700	
HY 32	1033.70	2.72	0.072	2750	
HY33	1033.87	7.34	0.105	2750	
HY 36	1034.55	1.51	0.173	2710	
[illegible]					
HY 7A	1023.65	6.66	0.175	2710	
HY 7B	1023.75	2.54	0.149	2710	
HY9	1024.10	0.99	0.163	2700	
HY 12	1024.55	10.5	0.134	2740	
HY14*	1024.95	3.02	0.129	2730	* Fractured sample
HY 16A	1025.40	2.29	0.147	2720	
HY 16B	1025.55	2.65	0.123	2740	
HY17	1025.60	12.04	0.166	2710	
HY 20	1026.46	11.3	0.122	2740	
HY21	1026.73	6.27	0.184	2710	
HY22A	1026.85	2.87	0.187	2700	
HY22B	1026.92	2.34	0.163	2700	
HY24*	1027.35	4.03	0.156	2720	* Fractured sample
[illegible]					
HY 16	1023.77	5.02	0.142	2670	
HY 33	1025.87	8.74	0.167	2680	
HY 41	1026.91	0.26	0.162	2670	

TABLE 2
ANDERSON - SOUTH PIERSON
FORMATION DAMAGE STUDY
CORE # HY7B, HY 16A - CRITICAL FILTRATION TEST

CORE AND TEST PARAMETERS			
Formation:	SOUTH PIERSON	Well I.D.:	12-9-002-29 W1M
Core Number:	HY7B, HY16A	Core Depth:	1023 - 1026
Length (cm):	8.92	Diameter (cm):	3.80
Effective Flow Area (cm^2):	11.34	Bulk Volume (cm^3):	101.20
Porosity (fraction):	0.15	Pore Volume (cm^3):	14.97
Routine Air Permeability (mD):	2.42	Absolute Brine Permeability (mD)	0.236
Test Temperature (C):	AMBIENT	Initial Water Saturation (%)	100
Back Pressure (kPag):	0	Net Overburden Pressure (kPag):	19990

TEST SUMMARY

Fluid Type	Permeability (mD)	Regain Permeability
0.2μm Sour Water	0.236	Baseline Permeability
0.5μm Sour Water	0.183	77.273
0.8μm Sour Water	0.159	67.160
2.0μm Sour Water	0.119	50.185
3.0μm Sour Water	0.110	46.416

99-143 (ml)

TABLE 3
ANDERSON - SOUTH PIERSON
FORMATION DAMAGE STUDY
CORE # HY7B, HY16A - CRITICAL FILTRATION TEST
PERMEABILITY SUMMARY

Field:	SOUTH PIERSON	Air Permeability (mD):	2.42
Formation:	Spearfish	Porosity(%):	14.80
Sample I.D.:	HY7B, HY16A	Pore Vol. (cc):	14.97

Test Fluid	Injection Volume		Permeability (mD)
	Cumulative (cc's)	Cumulative (P.V.'s)	
0.2 μm Sour Water	34.0	2.3	0.230
0.2 μm Sour Water	50.8	3.4	0.229
0.2 μm Sour Water	73.8	4.9	0.230
0.2 μm Sour Water	129.8	8.7	0.235
0.2 μm Sour Water	159.4	10.6	0.234
0.2 μm Sour Water	184.8	12.3	0.235
0.2 μm Sour Water	196.0	13.1	0.236
0.2 μm Sour Water	201.7	13.5	0.236
0.5 μm Sour Water	218.1	14.6	0.229
0.5 μm Sour Water	241.0	16.1	0.227
0.5 μm Sour Water	251.6	16.8	0.226
0.5 μm Sour Water	278.1	18.6	0.222
0.5 μm Sour Water	344.8	23.0	0.211
0.5 μm Sour Water	476.8	31.9	0.183
0.8 μm Sour Water	490.7	32.8	0.183
0.8 μm Sour Water	506.6	33.8	0.174
0.8 μm Sour Water	521.6	34.8	0.172
0.8 μm Sour Water	551.5	36.8	0.165
0.8 μm Sour Water	626.4	41.8	0.161
0.8 μm Sour Water	667.7	44.6	0.159
2.0 μm Sour Water	679.2	45.4	0.156
2.0 μm Sour Water	693.1	46.3	0.149
2.0 μm Sour Water	715.5	47.8	0.146
2.0 μm Sour Water	741.3	49.5	0.142
2.0 μm Sour Water	818.9	54.7	0.130
2.0 μm Sour Water	952.2	63.6	0.119
3.0 μm Sour Water	966.8	64.6	0.116
3.0 μm Sour Water	983.4	65.7	0.113
3.0 μm Sour Water	1024.5	68.4	0.111
3.0 μm Sour Water	1106.7	73.9	0.110
3.0 μm Sour Water	1147.0	76.6	0.110

99-143 (ml)

TABLE 4
ANDERSON - SOUTH PIERSON
FORMATION DAMAGE STUDY
CORE # HY7A, HY 21 - CRITICAL FILTRATION TEST

CORE AND TEST PARAMETERS			
Formation:	SOUTH PIERSON	Well I.D.:	12-9-002-29 W1M
Core Number:	HY7A, HY21	Core Depth:	1023 - 1026
Length (cm):	8.72	Diameter (cm):	3.79
Effective Flow Area (cm^2):	11.28	Bulk Volume (cm^3):	98.36
Porosity (fraction):	0.18	Pore Volume (cm^3):	17.79
Routine Air Permeability (mD):	6.40	Absolute Brine Permeability (mD)	1.639
Test Temperature (C):	AMBIENT	Initial Water Saturation (%)	100
Back Pressure (kPag):	0	Net Overburden Pressure (kPag):	19990

TEST SUMMARY

Fluid Type	Permeability (mD)	Regain Permeability
0.2μm Sour Water	1.639	Baseline Permeability
0.5μm Sour Water	1.901	115.964
0.8μm Sour Water	1.901	115.981
2.0μm Sour Water	1.840	112.245
3.0μm Sour Water	1.635	99.741

TABLE 5
ANDERSON - SOUTH PIERSON
FORMATION DAMAGE STUDY
CORE # HY7A, HY21 - CRITICAL FILTRATION TEST
PERMEABILITY SUMMARY

Field:	SOUTH PIERSON	Air Permeability (mD):	6.40
Formation:	Spearfish	Porosity(%):	18.10
Sample I.D.:	HY7A, HY21	Pore Vol. (cc):	17.79

Test Fluid	Injection Volume		Permeability (mD)
	Cumulative (cc's)	Cumulative (P.V.'s)	
0.2 μm Sour Water	60.2	3.4	1.753
0.2 μm Sour Water	118.2	6.6	1.746
0.2 μm Sour Water	152.2	8.6	1.713
0.2 μm Sour Water	242.0	13.6	1.701
0.2 μm Sour Water	265.0	14.9	1.676
0.2 μm Sour Water	320.0	18.0	1.639
0.5 μm Sour Water	380.7	21.4	1.614
0.5 μm Sour Water	410.3	23.1	1.679
0.5 μm Sour Water	463.1	26.0	1.736
0.5 μm Sour Water	511.1	28.7	1.819
0.5 μm Sour Water	551.5	31.0	1.848
0.5 μm Sour Water	609.7	34.3	1.893
0.5 μm Sour Water	672.3	37.8	1.901
0.8 μm Sour Water	737.6	41.5	1.907
0.8 μm Sour Water	804.4	45.2	1.867
0.8 μm Sour Water	840.8	47.2	1.916
0.8 μm Sour Water	898.0	50.5	1.954
0.8 μm Sour Water	954.8	53.7	1.933
0.8 μm Sour Water	992.1	55.8	1.918
0.8 μm Sour Water	1029.3	57.8	1.901
2.0 μm Sour Water	1078.0	60.6	1.910
2.0 μm Sour Water	1096.3	61.6	1.856
2.0 μm Sour Water	1114.0	62.6	1.835
2.0 μm Sour Water	1147.6	64.5	1.829
2.0 μm Sour Water	1182.2	66.4	1.846
2.0 μm Sour Water	1232.1	69.2	1.854
2.0 μm Sour Water	1272.1	71.5	1.846
2.0 μm Sour Water	1322.7	74.3	1.840
3.0 μm Sour Water	1370.8	77.0	1.785
3.0 μm Sour Water	1389.9	78.1	1.681
3.0 μm Sour Water	1414.1	79.5	1.627
3.0 μm Sour Water	1452.3	81.6	1.596
3.0 μm Sour Water	1507.8	84.7	1.612
3.0 μm Sour Water	1528.1	85.9	1.629
3.0 μm Sour Water	1583.0	89.0	1.635

TABLE 6
ANDERSON - SOUTH PIERSON
FORMATION DAMAGE STUDY
CORE # HY33/14-9 - FINES MIGRATION TEST with INJECTION WATER
CORE AND TEST PARAMETERS

Core Number	HY33/14-9
Depth (m)	1025.87
Field Name	S. PIERSON
Well Location	14-9-002-29 W1M
Length (cm)	3.808
Diameter (cm)	3.5505
Effective Flow Area (cm^2)	9.90
Bulk Volume (cm^3)	37.70
Porosity (fraction)	0.167
Pore Volume (cm^3)	6.30
Routine Air Permeability (mD)	8.74
Test Temperature (°C)	Ambient
Fluid Viscosity (mPa·s)	1.05
Back Pressure (kPag)	2750
Net Overburden Pressure (kPag)	19890

99-143 (ml)

TABLE 7
ANDERSON - SOUTH PIERSON
FORMATION DAMAGE STUDY
CORE # HY33/14-9 - FINES MIGRATION TEST with INJECTION WATER
PERMEABILITY STUDY

Laboratory Flow Rates	Equivalent Field Injection Rates		Effective Permeability (mD)	Effective Permeability (%) of baseline
	Vertical Well*	Horizontal Well**		
1 cc/hr	0.16 m^3/day	25.6 m^3/day	8.054	Base line flow rate
Post 3 cc/hr	0.5 m^3/day	76.7 m^3/day	5.570	69.2
Post 8 cc/hr	1.3 m^3/day	204 m^3/day	4.466	55.5
Post 16 cc/hr	2.6 m^3/day	409 m^3/day	3.160	39.2
Post 32 cc/hr	5.2 m^3/day	818 m^3/day	2.672	33.2
Post 64 cc/hr	10.4 m^3/day	1636 m^3/day	2.323	28.8

* For vertical well applications, the conversions is based on 4.0 meters of completed depth, perforation density of 13 jspm, perf. diameter of 2.5 cm and perf. depth of 30 cm.

** For horizontal well applications, the conversion is based on 600 meters of open horizontal leg, and a hole diameter of 10.2 cm.

TABLE 8
ANDERSON - SOUTH PIERSON
FORMATION DAMAGE STUDY
CORE # HY16B/12-9 - FINES MIGRATION TEST with INJECTION WATER
CORE AND TEST PARAMETERS

Core Number	HY16B/12-9
Depth (m)	1025.55
Field Name	S. PIERSON
Well Location	14-9-002-29 W1M
Length (cm)	4.519
Diameter (cm)	3.789
Effective Flow Area (cm^2)	11.28
Bulk Volume (cm^3)	50.95
Porosity (fraction)	0.123
Pore Volume (cm^3)	6.27
Routine Air Permeability (mD)	2.65
Test Temperature (°C)	Ambient
Fluid Viscosity (mPa·s)	1.05
Back Pressure (kPag)	2750
Net Overburden Pressure (kPag)	19890

TABLE 9
ANDERSON - SOUTH PIERSON
FORMATION DAMAGE STUDY
CORE # HY16B/12-9 - FINES MIGRATION TEST with INJECTION WATER
PERMEABILITY STUDY

Laboratory Flow Rates	Equivalent Field Injection Rates		Effective Permeability (mD)	Effective Permeability (%) of baseline
	Vertical Well*	Horizontal Well**		
2 cc/hr	0.32 m^3/day	51.2 m^3/day	0.625	Base line flow rate
Post 4 cc/hr	0.64 m^3/day	102 m^3/day	0.600	96.0
Post 8 cc/hr	1.3 m^3/day	204 m^3/day	0.466	74.7
Post 16 cc/hr	2.6 m^3/day	409 m^3/day	0.388	62.2
Post 32 cc/hr	5.2 m^3/day	818 m^3/day	0.550	88.0***
Post 64 cc/hr	10.4 m^3/day	1636 m^3/day	0.499	79.9***

* For vertical well applications, the conversions is based on 4.0 meters of completed depth, perforation density of 13 jspm, perf. diameter of 2.5 cm and perf. depth of 30 cm.

** For horizontal well applications, the conversion is based on 600 meters of open horizontal leg, and a hole diameter of 10.2 cm.

*** In laboratory tests, an increase in permeability usually indicates fines being produced through and out of the test core. In field situations, the depth of flow would not allow this phenomenon to occur and thus would have a net effect of a further decrease in permeability. A dashed line in Figure 6 is used to estimate this effect.

FIGURES

FIGURE 1
ANDERSON - S. PIERSON
FINES MIGRATION & SENSITIVITY APPARATUS

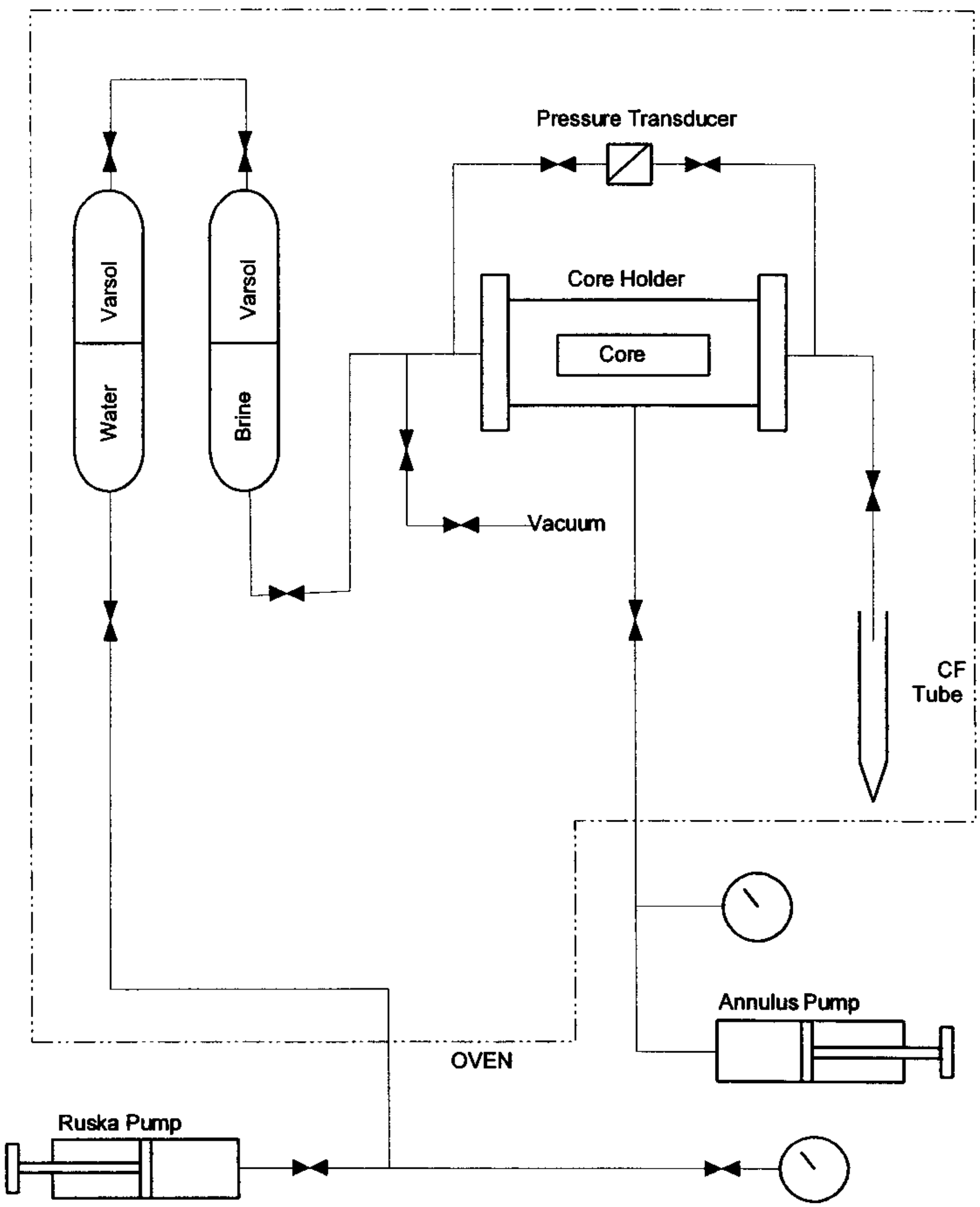


FIGURE 2
ANDERSON - S.PIERSON
CRITICAL FILTRATION APPARATUS

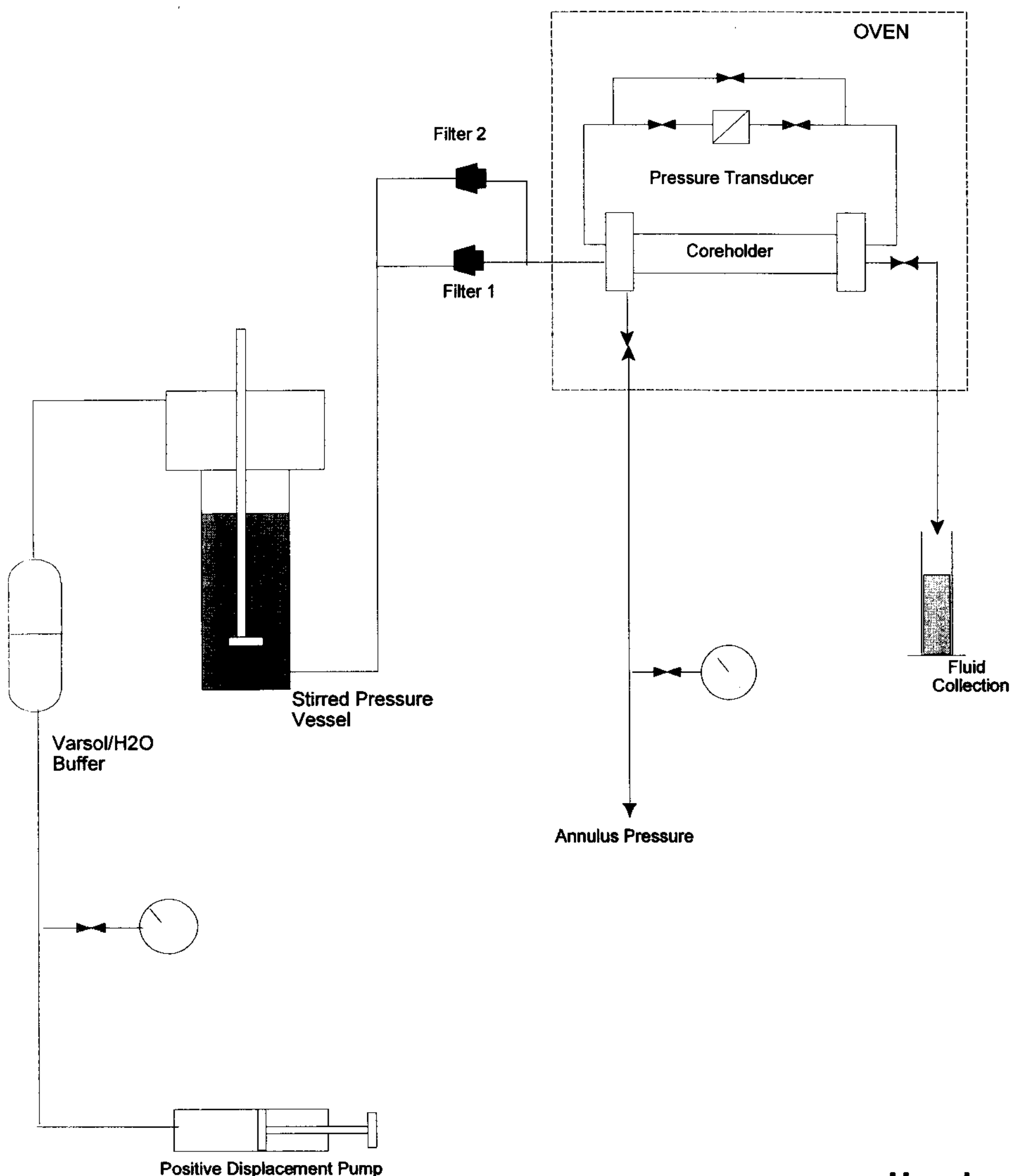
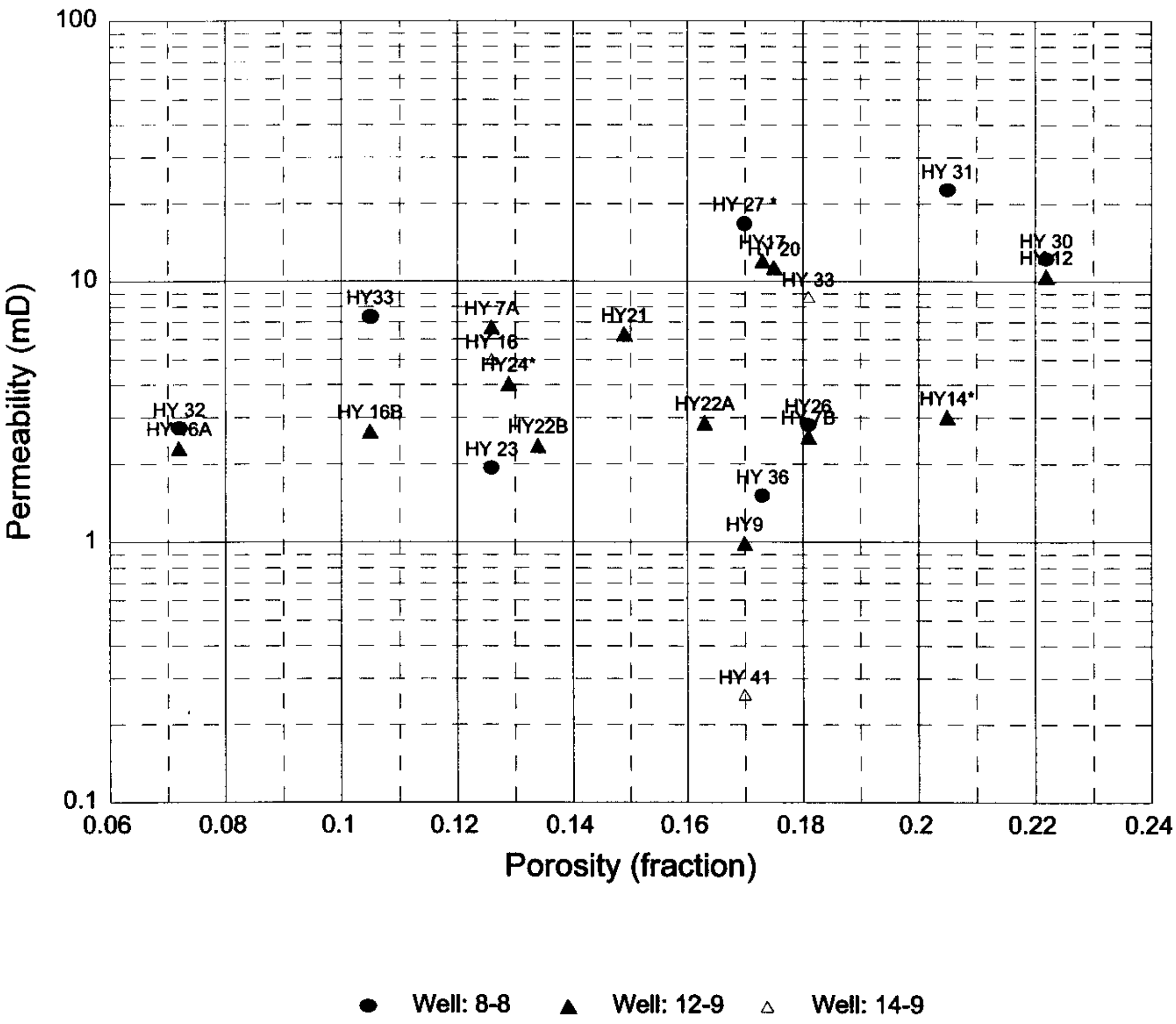


FIGURE 3
ANDERSON-S.PIERSON
FORMATION DAMAGE STUDY
ROUTINE CORE ANALYSIS



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Hycal

FIGURE 4
ANDERSON-S.PIERSON
FORMATION DAMAGE STUDY
CORE # HY7B, HY16A - CRITICAL FILTRATION TEST
PERMEABILITY PROFILE

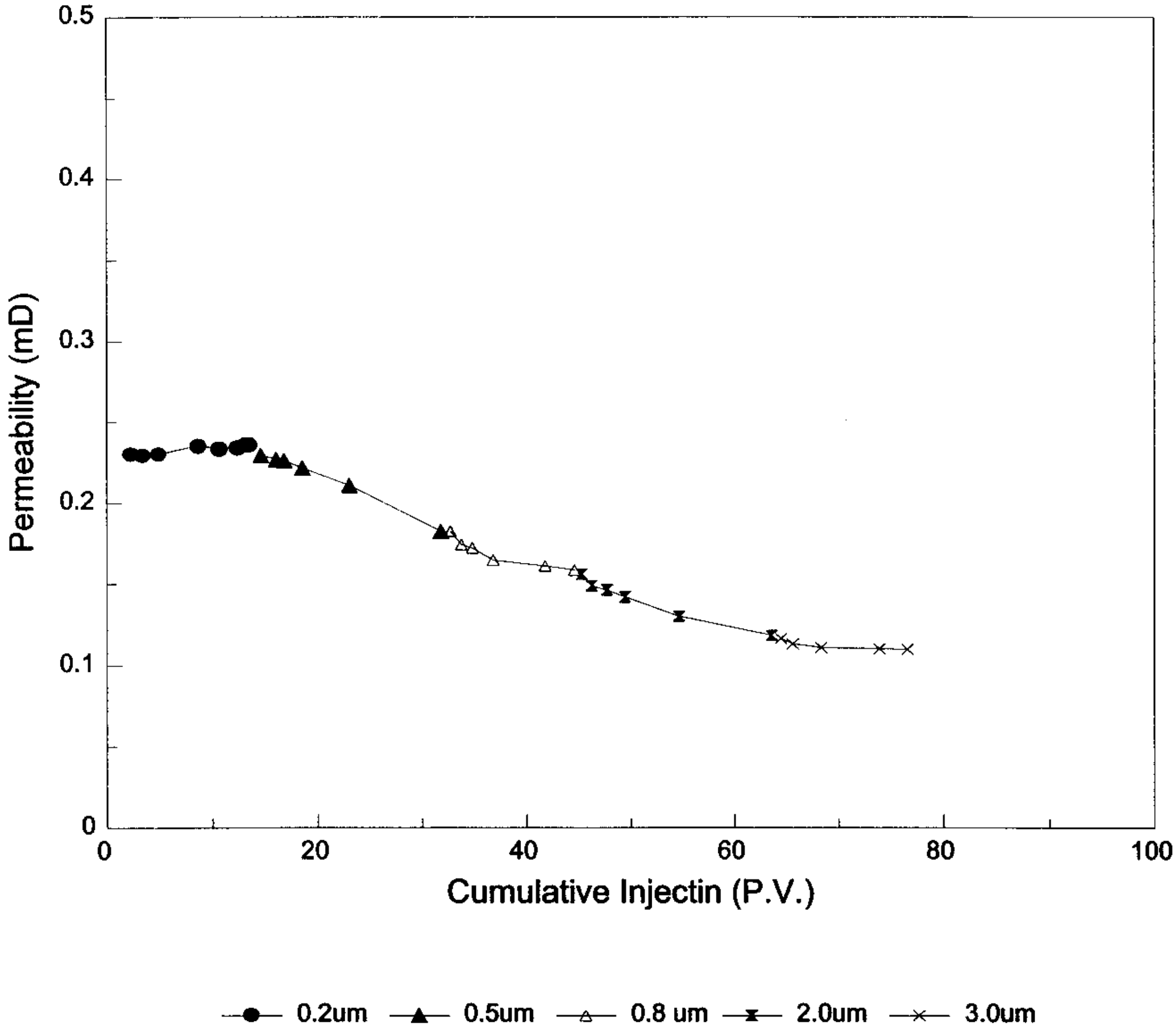

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FIGURE 5
ANDERSON-S.PIERSON
FORMATION DAMAGE STUDY
CORE # HY7A, HY21 - CRITICAL FILTRATION TEST
PERMEABILITY PROFILE

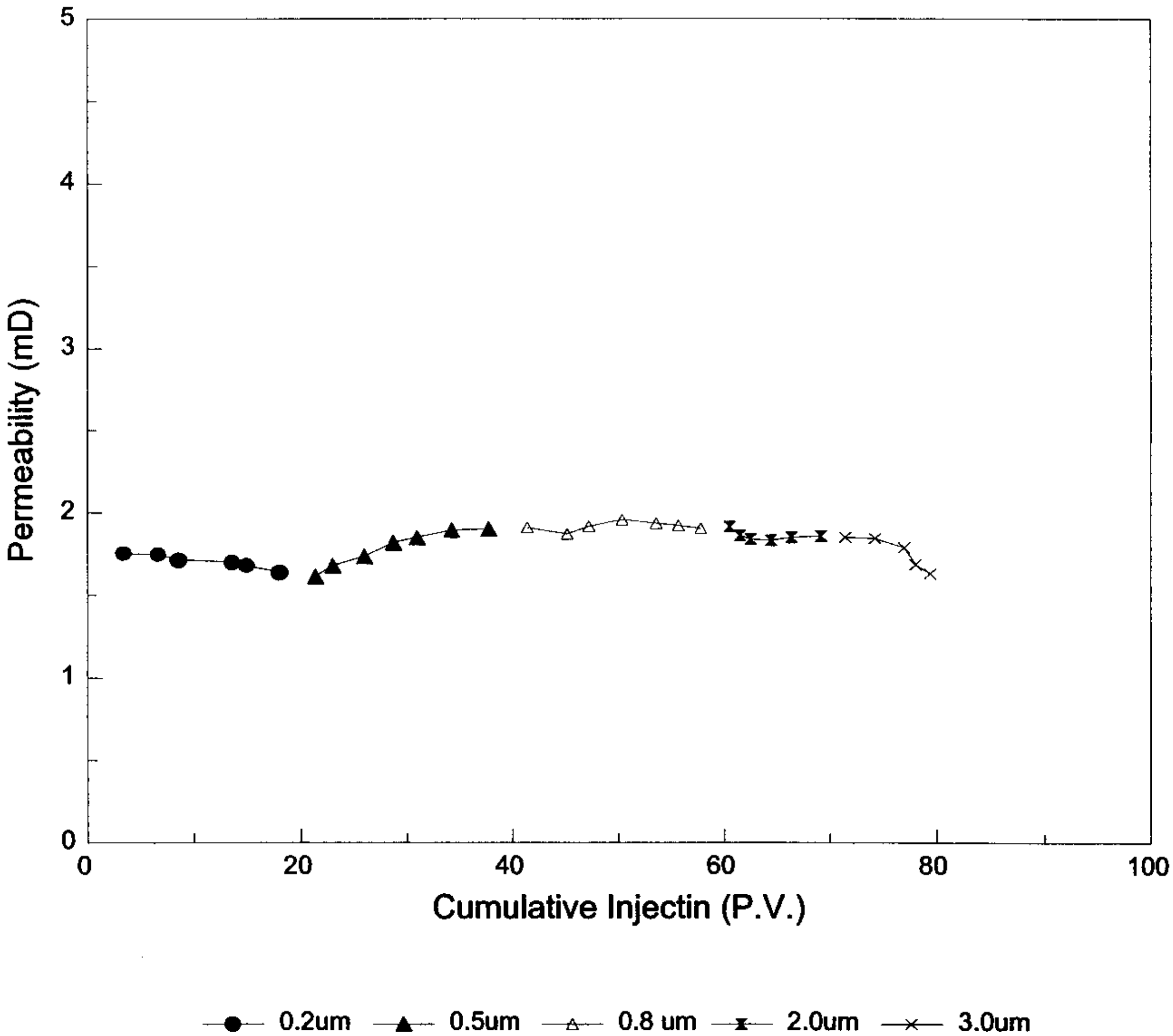

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FIGURE 6
ANDERSON-S.PIERSON
FORMATION DAMAGE STUDY
CORE # HY33/14-9 - FINES MIGRATION TEST WITH INJECTION WATER
PERMEABILITY VS LABORATORY FLOW RATES

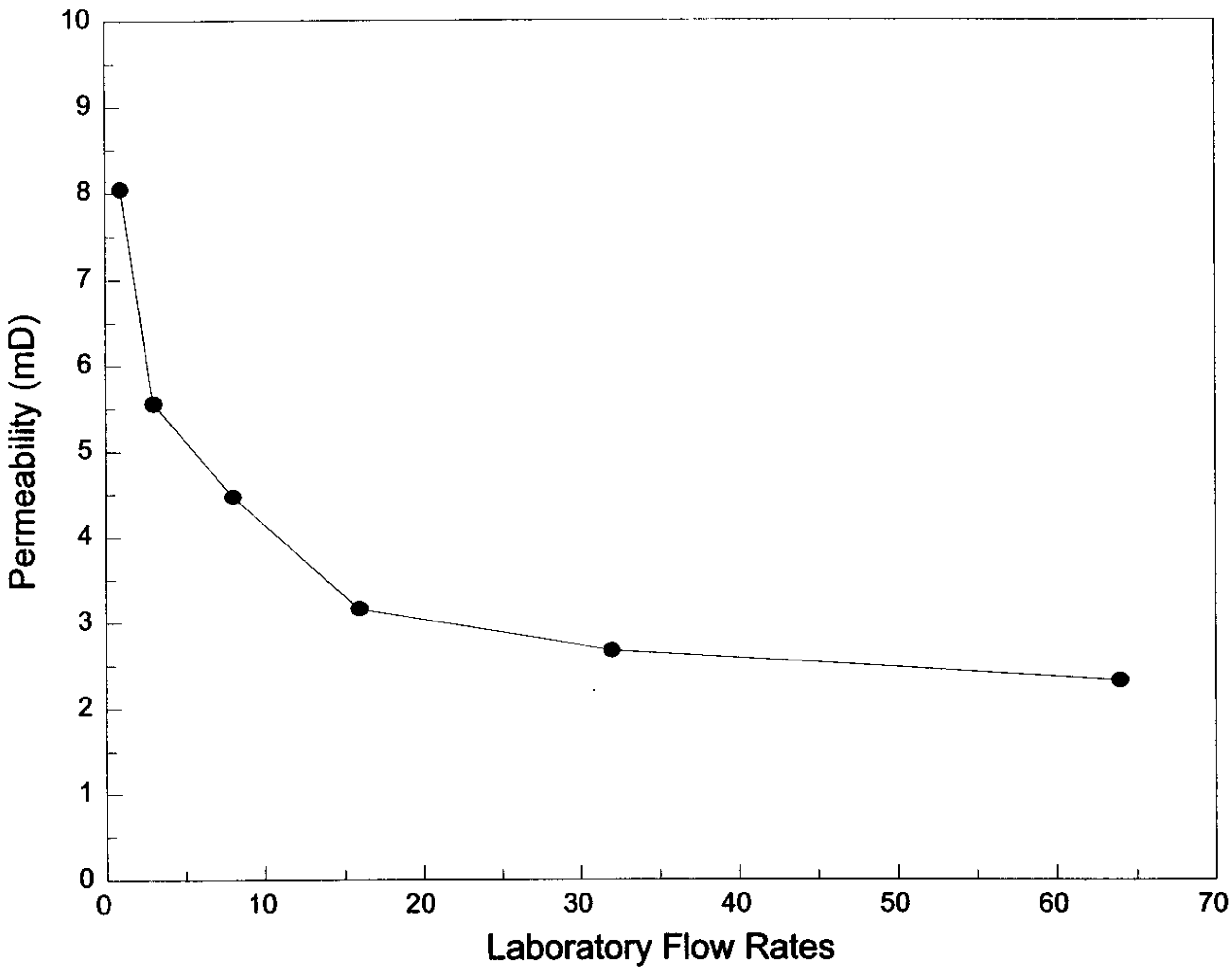

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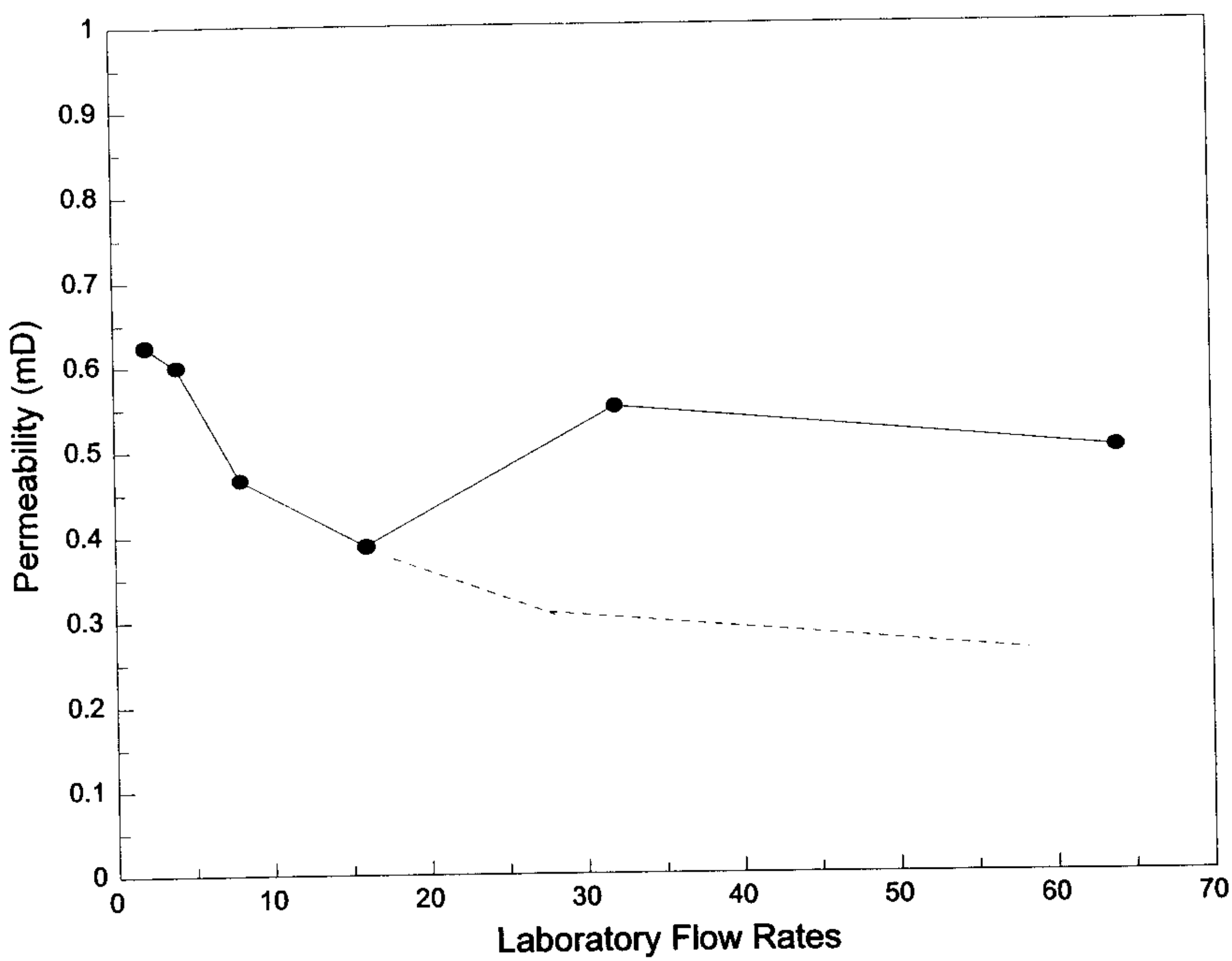
FIGURE 7
ANDERSON-S.PIERSON
FORMATION DAMAGE STUDY
CORE # HY33/14-9 - FINES MIGRATION TEST WITH INJECTION WATER
PERMEABILITY VS LABORATORY FLOW RATES



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